

# SIRAS-G: ESTC 2005 Mid-Program Progress Report

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## SIRAS-G: A NASA Instrument Incubator Program

- ❑ **SIRAS-G: Spaceborne Infrared Atmospheric Sounder for Geosynchronous Earth Orbit (GEO)**
  - SIRAS-G is an infrared sounder with high spectral resolution ( $\lambda/\Delta\lambda$ ) of 800 - 1400, operating in the 3.35 - 15.0 $\mu\text{m}$  band
  - Grating spectrometers are used for the fine spectral separation
  - The flight instrument divides this spectral range into 3 or 4 spectrometer channels, depending on intended application

Table 1. SIRAS -G Grating Spectrometers		
Spect	Band ( $\mu\text{m}$ )	Comments
1	3.35-4.8	Build in 2003 IIP
2	6.2-8.22	Design in 2003 IIP
3	8.8-12.0	Design in 2003 IIP
4	12.3-15.4	Built in 1999 IIP

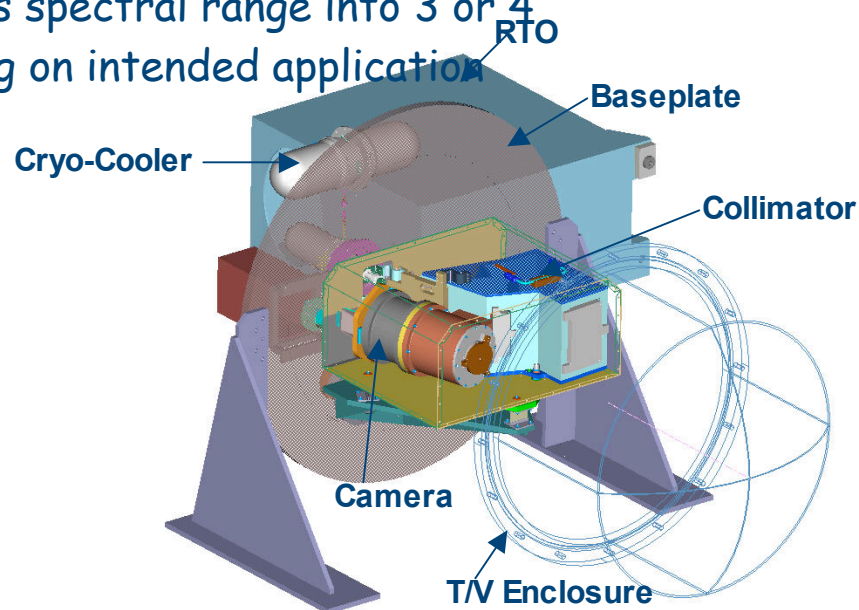


FIGURE 1. LAYOUT OF THE SIRAS -G LAB DEMO

## Spaceborne InfraRed Atmospheric Sounder for GEO

PI: Thomas U. Kampe / Ball Aerospace

### Description

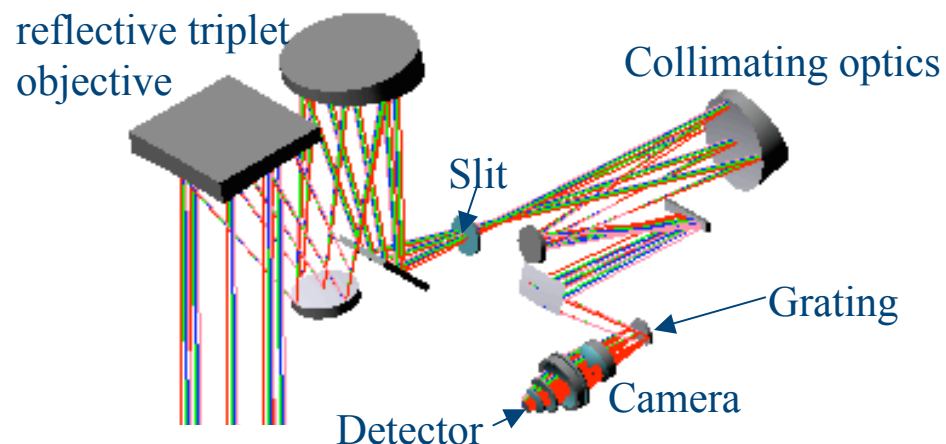
- Reflective/Refractive Wide field hyperspectral IR optical design:
  - maximizes signal collection efficiency
  - allows for compact instrument & low mass
- IR imaging spectrometer with very low spectral smile and keystone distortion
- Warm shield design reduces heat loads and minimizes active cryocooler requirements
- 2D FPA's: simultaneous spatial/spectral imaging
- Improved spatial resolution over heritage instruments allows more cloud-free observations

### Approach

- Design hyperspectral IR optical system
- Mate spectrometer assembly & Ball SB235 cryocooler
- Test radiometric and spectral response & sensitivity.
- Demonstrate spectrometer assembly (collimator, beamsplitters, spectrometer, dewar, FPA and cables) spectral response.
- Demonstrate warm shield performance
- Demonstrate BATC Proprietary test methodologies for smile, keystone distortion,

MTF, and Spectral Response Function (SRF)

## The Spaceborne Infrared Atmospheric Sounder for Geosynchronous Earth Orbit (SIRAS-G)



Optical design of the SIRAS-G Laboratory Demo Instrument

### Applications

- Primary - Atmospheric temperature, moisture and rainfall from GEO
- Secondary - Trace gas measurement from GEO
- Secondary - Temp, H<sub>2</sub>O, trace gases from LEO

### Partner/Collaborator Organizations

- Ball Aerospace & Technologies Corp. / Civil Space Advanced Programs - Earth Sciences
- Jet Propulsion Laboratory

## The Reflective Triplet Objective (RTO) is Complete

- ❑ RTO delivered to BATC on March 24, 2005
- ❑ RTO meets all performance requirements specified
- ❑ WFE is 0.20 - 0.30 waves RMS @ 632.8-nm
  - corresponds to approximately 0.03 to 0.047 waves RMS at operational wavelength of 4.0-  $\mu$ m

RTO during Optical Testing at Corning NetOptix



RTO Housing and Mirrors prior to final assembly

Veeco

Contour Plot

### Measurement Parameters

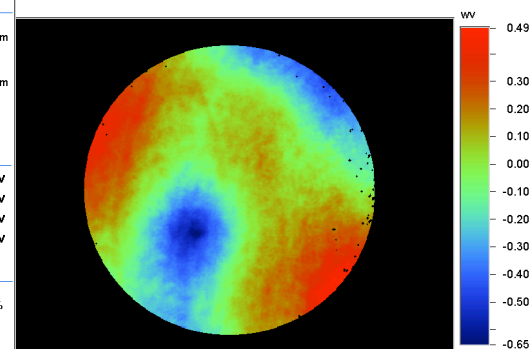
File: AS USED - ON-AXIS  
Wavelength 632.80 nm  
Wedge 0.50  
XYSize 736 X 480  
Pixel size 0.00  $\mu$ m  
Date 03/16/2005  
Time 09:42:39

### Analysis Results

Ra 0.173 wv  
Rms 0.214 wv  
20 Pt. PV 1.097 wv  
2 Pt. PV 1.15 wv

### Analysis Parameters

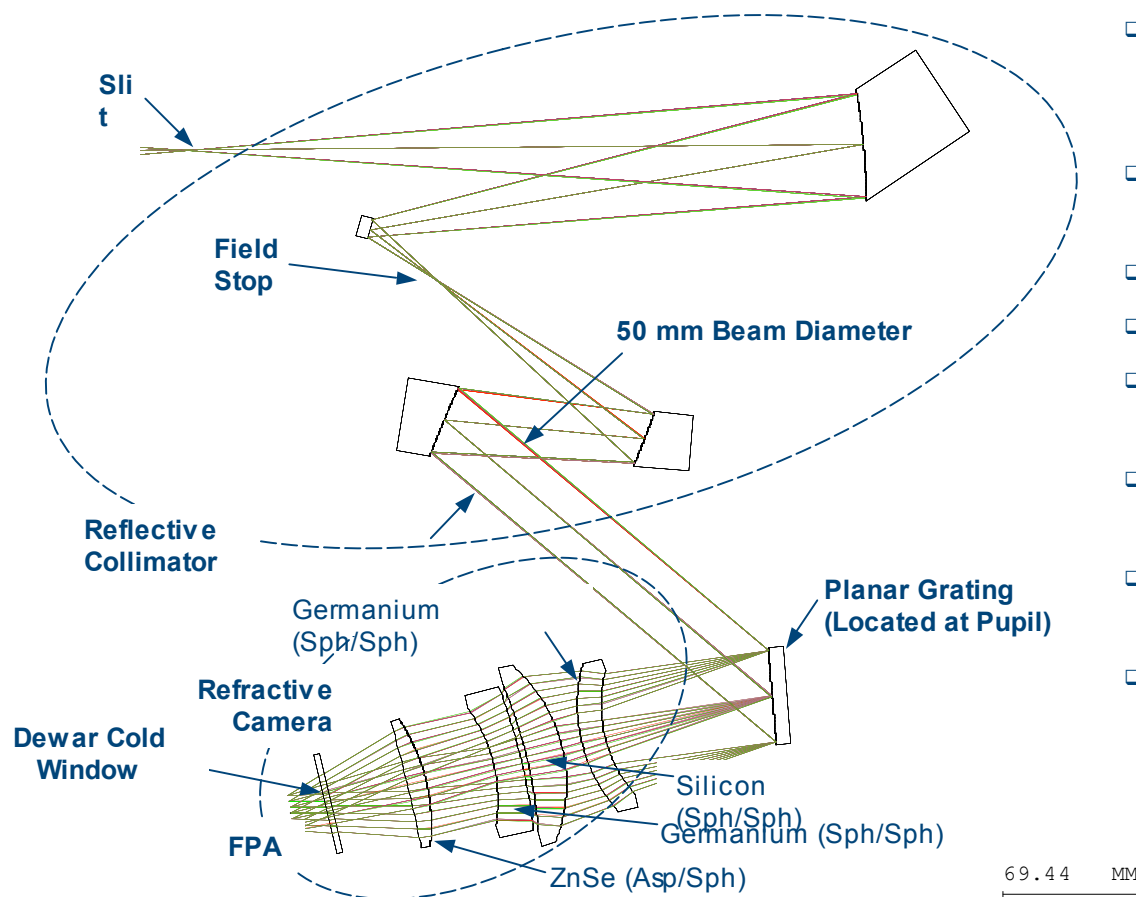
Terms Tilt  
Pupil 100 %  
Masks: Detector Mask  
Filtering None  
Data Restore No  
Valid Points 161020



WFE at 632.8 nanometers

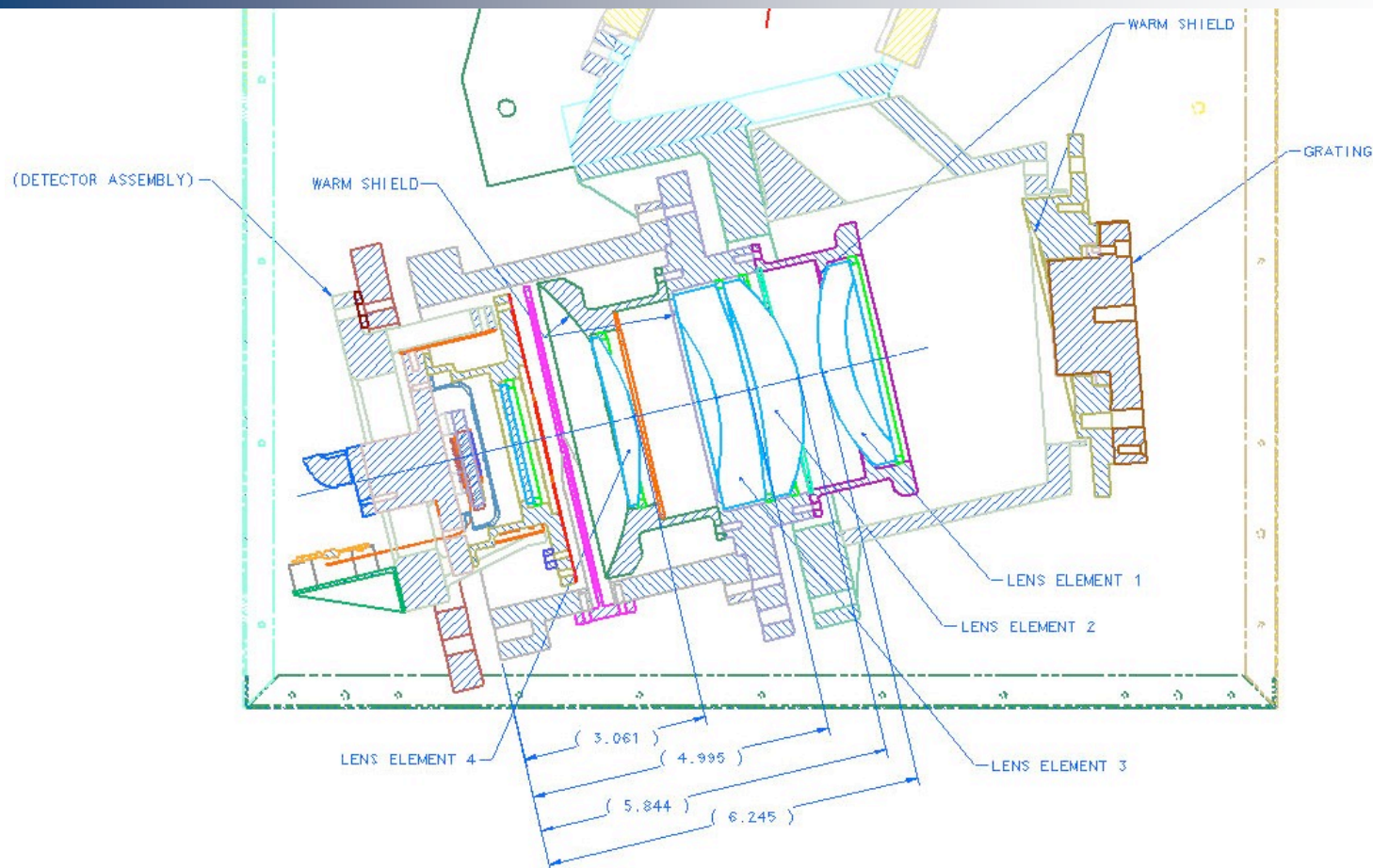
Title: SIRAS-G RTO  
Note: AS USED ON-AXIS

# Aft-Optics Design Controls Distortion on Large FPA



- ❑ Demo Instrument optical system designed for the RSC Hawaii 1-RG Array (1024x1024, 18 $\mu$ m pixels)
- ❑ Distortion controlled to less than 20% of a pixel over entire extent FPA
- ❑ 1024 x 1024 Format Array
- ❑ 0.018-mm Pixel Pitch
- ❑ Spatial and spectral resolution elements = 2 pixels
- ❑ Slit width = 2 pixels (Nyquist sampling)
- ❑ Slit length = 2\*18 mm = 36.0 mm, or 1000 pixels
- ❑ Slit image is smaller in length than FPA
  - Avoids illuminating inactive pixels or leads & wires around FPA
  - Provides margin for alignment of FPA to slit
  - Since ends of slit are on active pixels, alignment of the slit can be measured

## Camera Assembly Design Integrates Warm Shields

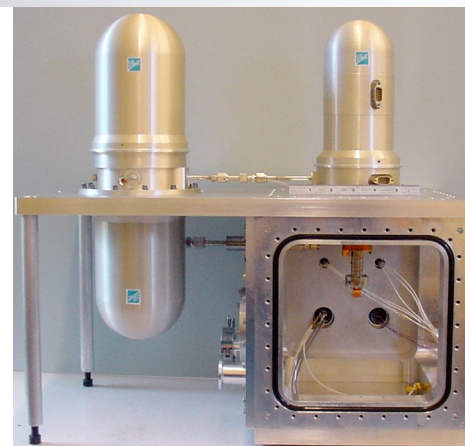


- ❑ Predicted thermal noise well fill <5.5% full well
- ❑ Tests planned with/without warm shield aperture stop
- yields warm shield performance

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# Ball SB235 Cryocooler Cools Detector and Aft Optics

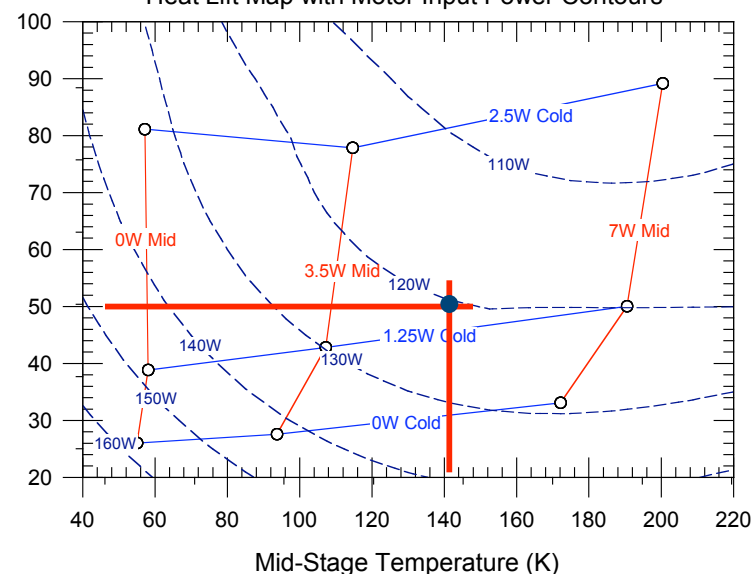
- ❑ FPA Assembly <50 K
- ❑ 140 K Aft-optics
- ❑ 10.5 kg
- ❑ Non-contacting operation
  - -60C to +80C
- ❑ 99% reliability at 10 years
  - SB235 life tests in progress
- ❑ 3rd Generation Multi-stage, 50 K Performance:
  - 1.4W @ 50 K
  - & 4.5W @ 140 K for 120 W motor
  - Excellent HIRDLS performance
- ❑ 1-g orientation insensitive
- ❑ Active vibration isolation to below 0.10 N
- ❑ High side loads tolerated using fixed-regeneration cold finger



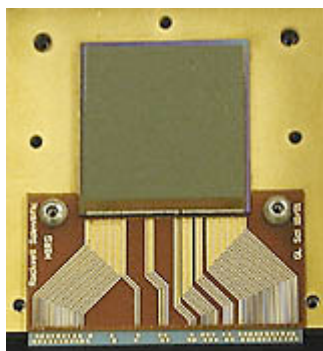
SB235 Higher Cooling Performance

90% Stroke - 39 Hz - 75°

Heat Lift Map with Motor Input Power Contours

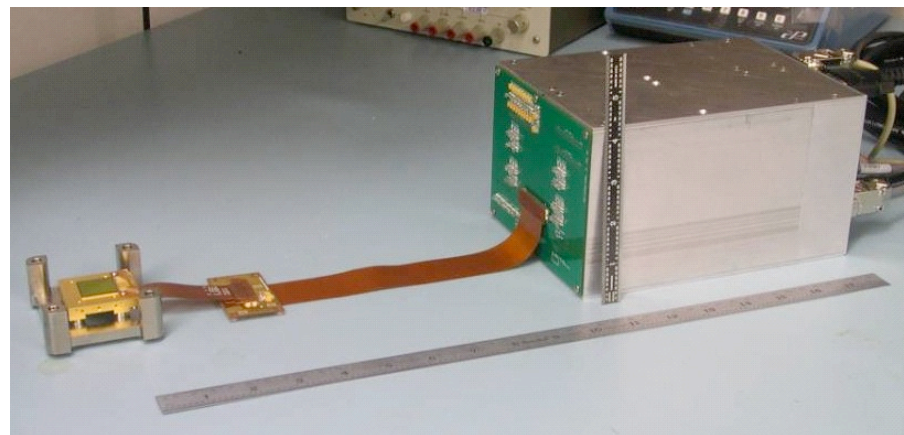


## IR Detector Ready For Delivery To Ball



Rockwell Hawaii 5.2-micron Cut-Off Infrared Focal Plane Array

1024 x 1024  
HgCdTe/CdZnTe



Detector Readout Electronics and Detector

### FPA Subcontract complete:

- ❑ 1024 x 1024 Hawaii-1RG MWIR FPA from Rockwell Scientific Company
- ❑ Includes read-out electronics and image processing system
- ❑ 9 month delivery
- ❑ Acceptance test complete - end to end @50K
- ❑ >65% (expect>80) responsivity (QE)
- ❑  $21e^-$  total noise @ 74Hz frame rate
- ❑ 4.7% non-uniformity



Detector Readout Electronics and Test Apparatus

- ❑ >98% of array useable

7/5/05

>200K $e^-$  well capacity

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## Mission Conceptual Studies Initiated

- First mission being studied is an AIRS Follow-On Mission
  - Low-Earth Orbit; enhanced spatial resolution
  - Mission focused on retrieval of atmospheric temperature profiles, water vapor profiles, ozone column and cloud properties
  - Spectral coverage and resolution optimized for these parameters

- Second study will focus on GEO  
Atmospheric Chem/Climate mission

### AIRS Follow-On Mission

#### Key Measurement Requirements:

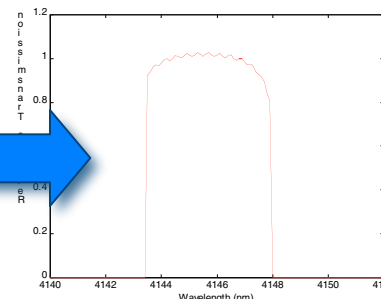
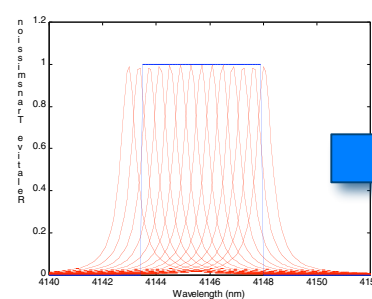
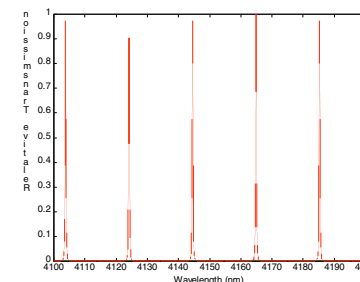
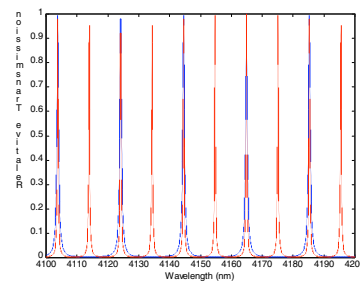
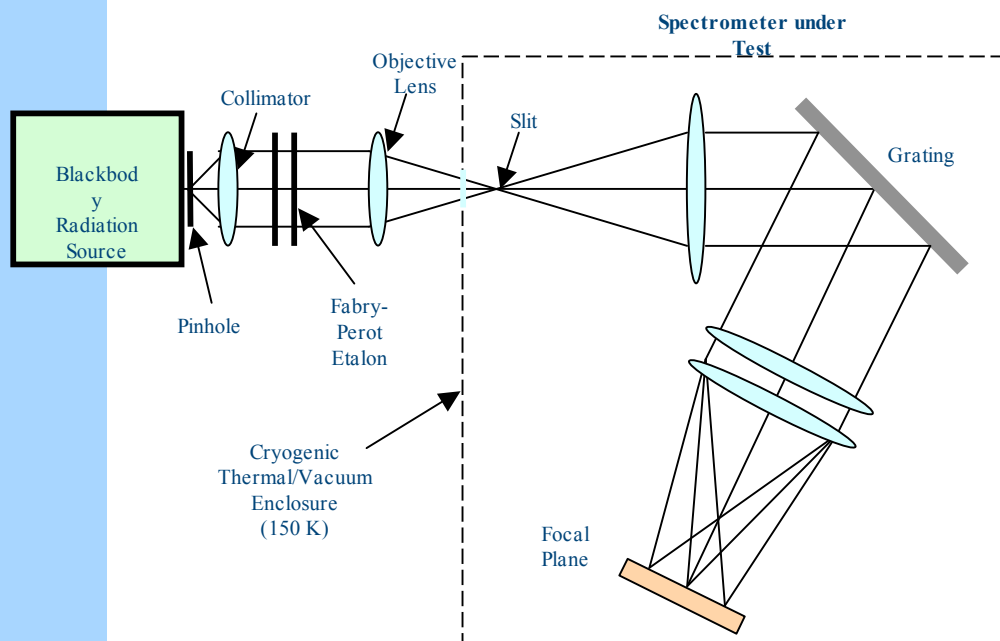
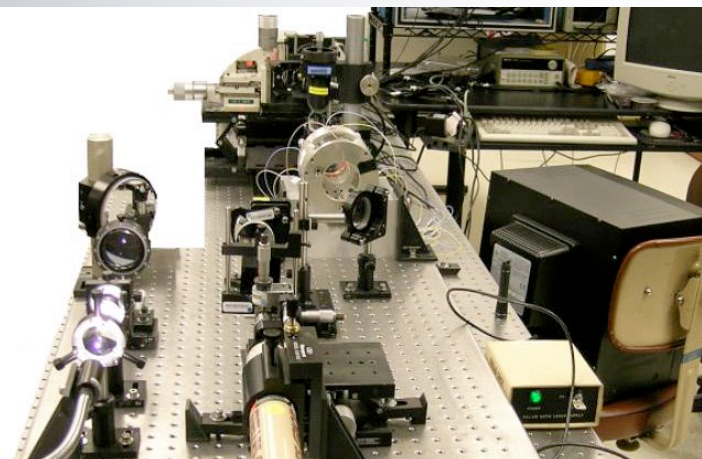
- Spatial resolution: 1-km
- Swath coverage: 1650 km (TBR)
- Radiometric Noise < 0.2K (TBR)

Measurement†	Accuracy (req.'ed : goal)
Surface Temperature	1K : 0.5K
Temperature profiles	1K (rms) (1-km layers < 100mb)
Humidity profile	20% : 10% (2-km layers < 100mb)
Column Ozone	20%

Measurement	Spectral Range (cm <sup>-1</sup> )	Min. res (cm <sup>-1</sup> )	Goal res (cm <sup>-1</sup> )	Notes
Temperature profiles	650 - 768 2228 - 2255 2380 - 2410	0.5 2.0 2.0	0.5	Higher spectral resolution improves T sounding throughout range
Humidity profiles	1370-1610	2.0	0.5	Weaker water lines near 2600 cm <sup>-1</sup> used AIRS
Ozone Column	1001-1069	0.5	TBD	Very high resolution necessary for profile info.
Surface Temperature	750-1200	~1.0	0.5	Several channels: 750-1235 cm <sup>-1</sup> and >2400 cm <sup>-1</sup>
Dust properties	750-1200	~1.0	0.5	Higher resolution improves UT/LS retrievals
Cloud properties	750-1200	~1.0	0.5	3 channels: 8,10,12 μm

## Fabry-Perot Etalon Test Approach Developed

- ❑ Tests broad range of Hyperspectral instruments
  - VIS/NIR thru LWIR
- ❑ Patent Application submitted
- ❑ Direct measure of SFR



## Summary

- ❑ BATC's 3 year effort is half complete
- ❑ Major procurements are complete or in progress
- ❑ Initial performance studies indicate high quality temperature, water, ozone retrievals are achievable with 1km spatial resolution
- ❑ Study in progress to determine LEO applicability
- ❑ Laboratory demonstration unit delivers on low volume, low mass promise
- ❑ Large format detector arrays allow high spectral and spatial resolution on broad spatial extent